Research on Air-sending Characteristics Simulation of Air-conditioning System of Air-conditioning Support Equipment for Airplane

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Keywords: air-conditioning vehicle for airplane, air-condition system, air-sending characteristics, TRNSYS

Abstract: Aiming at moisture condensation of air-conditioning support for airplane, this paper analyzes air-conditioning system of air-conditioning support equipment for airplane theoretically, and sets up the air-conditioning simulation model through the Transient System Simulation Program (TRNSYS). Then the influence of different enthalpy humidity ratio and weather conditions to energy consumption are analyzed. Finally the security and efficiency of supplied air state is discussed, which improve air-condition support efficiency of airplane.

1. Introduction

With the frequent use of aircraft ground air conditioning support equipment, the problem of ventilation and dew in the aircraft during the support time has been gradually attracting people's attention. Ventilation and dew problem will affect the performance of the internal electronic equipment, and become a flight safety hidden danger. This paper analyzes the air supply characteristic of air supply system of aircraft ground air conditioning support system, and finds the safe and efficient air supply condition under the premise of satisfying the air supply requirement.

2. Theoretical Analysis

Air firstly goes through the air filters, into the first stage air conditioner, which scatters some heat. Then, the air goes through the first silencer into the fan, which increases the air pressure. After the air goes through the second silencer, the air enters the second stage air conditioner to meet the set ventilation temperature and humidity requirements [1]. The working principle of air conditioning system for aircraft ground air conditioning support is shown in Figure 1.

Air-conditioning system of aircraft ground air conditioning support is two-stage air-conditioning box. The first-stage air-conditioning box consists of a steam-compressed refrigeration cycle. The secondary air conditioner box is composed of two levels of steam compression refrigeration cycle, which mainly condenses and dehumidifies the air supply air and bears the remaining thermal and latent heat loads [2].
In theory, the air supply point of the aircraft's equipment module is related to the state of the environment and the amount of air supply, shown in Equation (1).

\[
S(h_s, d_s) = f(h_w, d_w, G, W, t)
\]  

(1)

In Equation (1), \(h_w\) is the enthalpy of the state of the environment; \(d_w\) is the moisture content of the environmental state; \(h_s\) is the ideal temperature range for aircraft equipment module; \(d_s\) is the ideal moisture content range for aircraft equipment module; \(G\) is the air supply; \(t\) is the ventilation time; \(W\) is the total energy consumption for the system [3].

From the above formula, aircraft ground air conditioning support equipment air supply characteristics affect the quality and speed of flight support, but also affect the performance of air conditioning system. The air temperature and relative humidity of the air in the cabin are not required to be accurate to a certain point in the actual course of the safeguard. The air-transmitting state is also an interval, and there is a large difference between the air-transmitting regions. When the air from the cold air meets the air in the wet cabin, white fog tends to condense into water droplets, which can corrode electronic equipment [4]. Therefore, in the aircraft ground air conditioning support equipment, air conditioning needs to dehumidify the aircraft interior.

3. Simulation of Air Supply Characteristics of Aircraft Ground Air Conditioning Support Equipment

According to the air conditioning system flow chart of aircraft ground air conditioning support system, the simulation model is established. In the simulation model, a Type 506c evaporator and a Type 167 compressor is used as the first stage of the air conditioner, setting the temperature of the Type 506c evaporator to 10-15ºC. The Type 506c-1 and Type 506c-2 evaporators and the Type 167-1 and Type 506c-2 compressors as the second stage air conditioners PID is used as the controller of air conditioning system for traditional aircraft air conditioning system. Two Type 65c plotters are selected to output the simulation results. Type 167 means a refrigeration compressor with a refrigeration capacity of 30kW. Then set evaporation temperatures of Type 506c-1 and Type 506c-2 to 5ºC. The simulation model of aircraft ground air conditioning support equipment air conditioning system is shown in Figure 2.
4. Simulation Analysis

In wet conditions, if the air temperature is too low, there will be ventilation and dew problems inside the aircraft. The larger the air temperature difference is, the longer the time of ventilation dehumidification will be. However, the smaller the air temperature difference is, the longer the air cooling time will be, affecting the efficiency of safeguards. The best air supply temperature difference is just the maximum moisture content to prevent dew in the aircraft, thus avoiding the excessive ventilation time and preventing the occurrence of ventilation dew problem.

The aircraft ground air support equipment set air moisture content of 8g/kg and 6g/kg dry air respectively, analysis at different times of the aircraft moisture change, shown in Figure 3.
When air conditioning systems are equipped with aircraft ground air conditioning systems with a wetting capacity of 6g/kg, the final moisture content of the aircraft is 7.58g/kg, and the time corresponding to the time of intersection of the non-exposed moisture in the electronic equipment module is 10 min, which is the minimum ventilation dehumidification time in the air conditioning system. The air conditioning system needs at least 10 min air drying in the aircraft equipment module and in the cabin. In order to make the air moisture content of the aircraft to the air temperature goes below the dew point, avoiding the problem of dew in aircraft is needed. When the moisture content of the air supply is 8g/kg, the final moisture content of the aircraft is 8.55g/kg, and the time corresponding to the unexposed moisture content of the aircraft cabin is 12 min, which is the minimum ventilation dehumidification time in the aircraft air conditioning system.

When the ventilation time increases, the moisture content in the aircraft will be decreasing and stabilizing. With the increasing of air moisture content, the final moisture content in the aircraft will increase gradually.

The aircraft equipment cabin will produce heat, assuming that the aircraft electric current inspection of the heat production is certain during aircraft ground electric current inspection. It then can determine the aircraft ground air conditioning equipment air supply and ventilation time relationship. In the process of aircraft ventilation, air supply system for aircraft ground air conditioning is mainly determined by the heat production in the aircraft equipment cabin. The heat production, volume and ventilation time of the aircraft during the electric current inspection will be determined, and the air supply of the air conditioning system is mainly related to the air supply temperature. Figure 4 shows the effect of different air supply temperatures on ventilation dehumidification.

![Figure 4 The effect of different air supply temperatures on ventilation dehumidification.](image)

Figure 4 shows that the air supply volume decreases with the increase of the minimum ventilation time according to the same air supply temperature, but the trend slows gradually, indicating that the air supply time has a smaller influence on the air supply volume. For the same air supply time, the amount of air required by the aircraft decreases with the decrease of air supply temperature.

At the same ventilation guarantee time, the air supply at the 20 °C air supply temperature is 1.4 times the new air supply at the 15 °C air supply. With the increase of air supply temperature, the energy loss of air conditioning system is also increased. Therefore, aircraft ground air conditioning
support equipment air conditioning system to reduce air temperature, to reduce ventilation support time, improve aircraft ground air conditioning support efficiency.

5. Conclusion

In order to study the air supply characteristics of aircraft ground air conditioning support system, this paper establishes the TRNSYS simulation model and studies the relationship between the air-sending characteristics and the ventilation time during air conditioning support system.

(1) As the ventilation time increases, the moisture content in the aircraft decreases and becomes stable. With the increasing of air moisture content, the final moisture content in the aircraft increases gradually, and the minimum ventilation time increases, which is greater.

(2) According to the same air supply temperature, the air supply volume decreases with the increase of the minimum ventilation time, but the trend slows gradually, indicating that the air supply time has a smaller influence on the air supply volume. For the same air supply time, the amount of air required by the aircraft decreases with the decreasing of air supply temperature.

References